also really be of assistance to the comparatively few picked students who will well repay any opportunities placed in their path for advanced study and subsequent research in applied science.

That there is no difficulty in getting students to travel, as has been suggested, is borne out by an appendix to the last report of the Manchester Committee for Technical Instruction. It is there set forth that last year there were, among the 4313 students of the technical school, no fewer than 2266 students from out-districts, of whom 18 came from Bolton, 25 from Bury, 44 from Oldham and Hollinwood, 16 from Rochdale, 348 from Salford, and 43 from Stockport, to name only a few towns from a long list in the report before us.

It is not recognised sufficiently that the technical education this country stands in need of is not elementary instruction in pure science. It has been demonstrated again and again in these columns that such teaching is really a part of every reasonable system of secondary education. When this is fully understood, the large classes in elementary science subjects will disappear from our technical schools. In their place we shall have students at work who, before entering the technical school, have become familiar with the broad principles of physical and chemical science, and who are now in a position to turn their attention to technical science—the application of pure science to the industry with which the student is connected.

Such a policy as has been indicated would make another desirable development possible. A specialisation of function on the part of schools in different towns could then be encouraged where necessary. Given a thoroughly representative authority for a sufficiently large area, and the apparent necessity of a class in every conceivable subject for each borough disappears. Each important technical school will be able to bend its efforts to solving the question of the proper form of technical instruction for one particular industry, or part of an industry. And Manchester, with the large number of great towns in its immediate neighbourhood, is an ideal district in which to begin some such sensible and economical supply of technical education. By all means let us have a generous supply of elementary evening classes in every town, but do let it be borne in mind that this work should only be regarded as preparatory. The serious need is for more centres where advanced students are looked after.

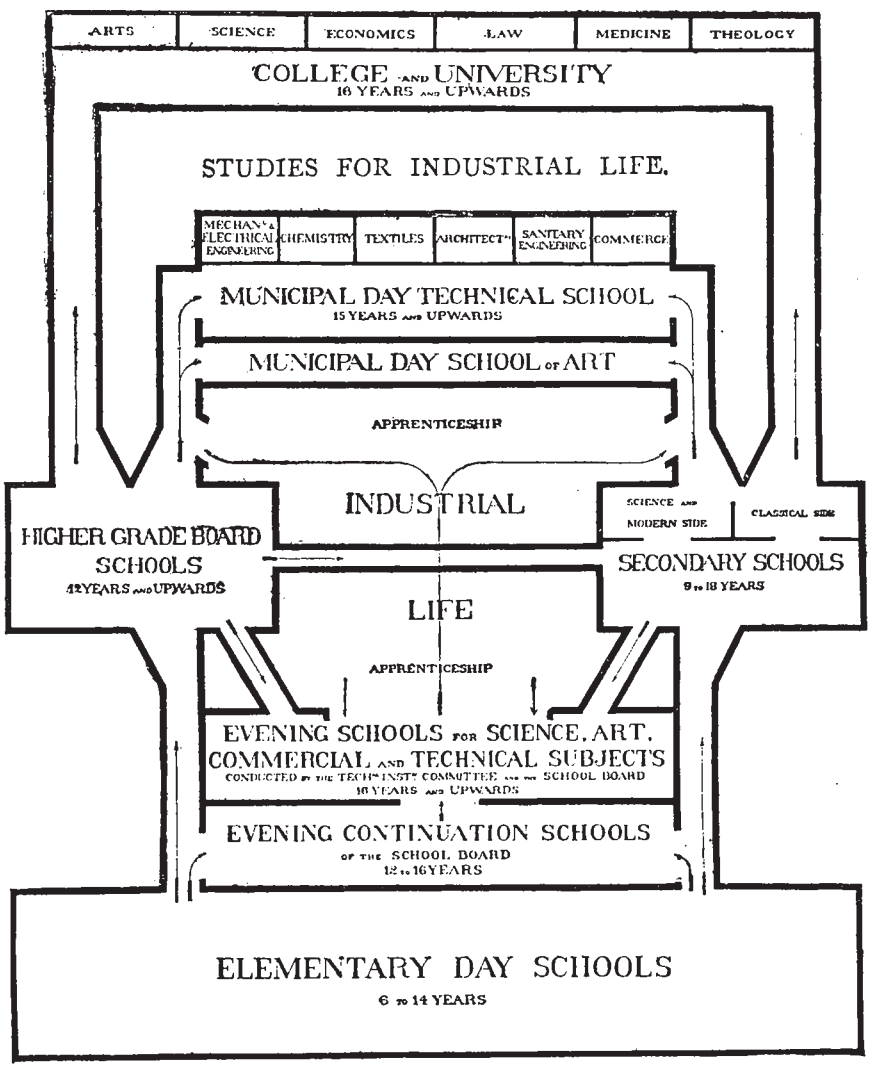

DIAGRAM ILLUSTRATING THE CORRELATION OF EDUCATION IN THE CITY OF MANCHESTER

In conclusion, another instance of the enterprise of the Manchester Committee must be mentioned. At the instigation of their Director they have secured for exhibition in Manchester the fine educational collection which the American Government sent to the Paris International Exhibition. Invitations to teachers and others interested in education to come and examine this unique collection of objects are being sent far and wide. It cannot but have a good effect to show English educationists some of the ways in which America is in advance of us in this matter of training intelligent workmen. A. T. SIMMONS.

METHODS OF FORMATION OF HAIL.[1]

THERE are many reasons for believing that hailstones are formed in the free atmosphere by some one of several different processes, each of which may be in accord with the laws of thermodynamics :—

(1) An ascending mass of air may be so dry that it does not cool to the dew-point until far below the freezing temperature, in which case the deposit is either fine spiculæ of ice or aggregations of these into small snowflakes.

(2) If the dew-point is a little higher than the preceding, the cloudy condensation may occur at temperatures just above the freezing point, and the watery particles may be carried up a little higher and frozen into what is called frozen fog. These same particles, when driven by the wind against an object, accumulate on it as frostwork.

(3) When a rising mass of air forms a large cumulus cloud at a low level, having a rapidly ascending current in its interior,

[1] Abridged from a contribution by Prof. Cleveland Abbe to the U.S. *Monthly Weather Review.*

the latter, by its buoyancy, will rise much higher than if there were no cumulus cloud; it may pass upward into the so-called hail region, where water drops and ice particles may coexist, and still higher up into the region where only ice and snow can exist.

(4) Raindrops falling from relatively warm clouds through a very cold stratum of air below may be frozen into sleet before they reach the ground.

To these four elementary methods of forming atmospheric ice we have to add the mechanical processes by which the small particles accumulate as large hailstones. Undoubtedly much light was thrown upon this subject by the notes made by observers on Pikes Peak during the early years of the occupation of that station.

In the thermodynamic studies of Hertz and von Bezold is employed the expression "the hail stage," viz. that stage in which the temperature of 32° prevails in an ascending mass of moist air. It is supposed that the ascending air, having already cooled to the dew-point, is carrying up with it a quantity of water, either in small cloud particles or in large raindrops. When these have ascended to the level where the rising moist air is cooled to the temperature of freezing, they continue to give up to the air a little of their specific heat until they are themselves frozen into hail or sleet. There is, therefore, a thin layer of air in which this process of freezing is going on and where the rising mass of mixed air and rain is kept at a uniform temperature until all the water is converted into ice. This is spoken of by Hertz as the hail stage; below it is the rain stage and above it is the snow stage. In this latter region the ascending air, being already cooled below the freezing point, can deposit its moisture only as snow or small crystals of ice. Now the actual hailstones observed on Pikes Peak are so frequently composed of snow that has been partly melted and refrozen, or mixed with water drops and refrozen, that we cannot suppose them to have been wholly formed within the thin layer known as the Hertzian hail stage. It is more likely that they are formed partly within that and partly within the Hertzian snow stage. The memoir of Hertz assumes throughout that the changes of temperature within the ascending air are strictly adiabatic. This requires that the ascent be so slow that the drops of water carried upward maintain the same temperature as the surrounding air. But these two conditions are almost physically incompatible; it is probable that neither of them are ever realised in nature. Among other combinations that are possible and may help to explain the great variety of forms of hailstones that are caught upon the summit of Pikes Peak, we may suggest the following as the most common:—

(1) Frozen raindrops carried very rapidly upward through the Hertzian hail stage may continue on into the snow stage and grow by the accretion of snowflakes until they are finally dropped to the earth, in which latter process they continue increasing their snowy covering. If, however, they pass through the hail stage before they reach the ground in their fall, they will be found to consist of an icy nucleus surrounded by a snowy envelope and covered over all by a layer of a frozen mixture of ice and snow.

(2) Air that has ascended into the snowy stage without going through the rain or hail stage, or, at least, to a very slight extent, because of its dryness, may form large snowballs high above the Peak before beginning to fall. As such balls descend very rapidly, the interior retains a low temperature, while the exterior is slightly warmed and melted by the action of the warmer air that the snowballs find near the ground. The result is large hailstones, consisting each of a thin layer or crust of ice and a snowy mass within.

(3) In the formation of snow and hail in the midst of ascending currents of air, we must expect to notice the same phenomenon as in the formation of rain, viz. after the first condensations have taken place upon dust and foreign substances the rising mass of cloud represents dustless air in the presence of water particles, but cooled by expansion to such an extent that the air between the drops, or the ice spiculæ, is in a state of supersaturation. When this condition has become too intense, large quantities of aqueous vapour suddenly condense, rushing together into large drops of rain or large masses of snow, and carrying with them all the finer particles within their respective spheres. At the very low temperatures at which this occurs, water will hold considerable air in solution, and additional air is also included at the centre of the snowball among the particles of snow and ice. Such large snowballs are heavy enough to descend rapidly from the snowy stage, through the rain and hail stages to the ground, and in so doing they become saturated with water which recrystallises forming solid hailstones, but at the centre of the mass they still hold, confined, the air originally included in the snowball, and this is compressed under several atmospheres, as was shown in 1869, by P. Reinsch (see *Pogg. Ann.*, 1871, or *Phil. Mag*, 1871, vol. xlii. p. 79), who observed that when such hailstones are melted under water the little bubble of air at the centre is seen to suddenly escape and expand sufficiently to demonstrate the existence of a pressure of fifty atmospheres under which it was confined. In this formation of snowballs and the resulting hail from supersaturated air within the snow stage there is an electric disturbance entirely analogous to that which takes place when great drops of rain are formed within the rain stage. In both cases violent thunder and lightning are observed just before the fall of the hail or the rain.

These and other hypotheses that might be framed relative to the methods of formation of the various kinds of hailstones must, however, only be regarded as suggestions intended to stimulate experimental and theoretical research in this direction. One cannot doubt but that the history of the formation of hail is written in its structure if we could but interpret it.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—Prof. W. J. Sollas has been elected to a fellowship at University College. This fellowship, however, is not to be regarded as attached to the professorship of geology; the election concerns the present professor only, the College being under no obligation to his successor.

Prof. Townsend, the new Wykeham professor of physics, has come into residence, but the space intended for his laboratory will not be available until the Radcliffe Library has been transferred to its new building.

CAMBRIDGE.—The Clerk-Maxwell studentship in physics, tenable at the Cavendish Laboratory, has been awarded to Mr. H. A. Wilson, Trinity. Mr. P. V. Bevan has been appointed assistant demonstrator in physics, in succession to Prof. Townsend. Mr. J. C. M. Garnett has gained the Sheepshanks astronomical exhibition at Trinity College. Mr. L. Whibley, Fellow of Pembroke, has been appointed assistant to the secretary of the University Press Syndicate. Mr. Yule Oldham, Reader in geography, is lecturing this term on the hydrosphere, and on the geography of Central Europe. A grant of 50*l.* for the current year has been made to the Department of Pathology, towards the course of instruction in bacteriology for the diploma in public health.

THE Report of the U.S. Commission of Education for the year 1898-99 has been received. It is a volume of thirteen hundred pages, containing papers and statistics on many branches of educational activity in various countries. Among the subjects of papers of interest in connection with instruction in sciences are school gardens, by Herr E. Gang; the teaching of geography, by Dr. A. J. Herbertson and others; manual training in Germany; minor mental abnormalities in children as occasioned by certain erroneous school methods; and an annotated chronological list of American text-books on arithmetic, prepared by Drs. J. M. Greenwood and A. Martin.

SCIENTIFIC SERIALS.

Symons's Monthly Meteorological Magazine, January.—Heavy rainfall of December 30, 1900. The official weather charts showed that the centre of a barometric depression lay over the middle of Ireland in the morning of that day, and that it moved southeastwards, passing Bristol in the early evening, and reaching the English Channel on the morning of the 31st. This storm was remarkable for the heavy rains which fell in the valley of the Severn and its tributaries. Falls exceeding two inches in 24 hours occurred over a broad diagonal belt from the mouth of the Severn to the mouth of the Humber, while amounts exceeding three inches occurred in a narrow strip running for about 85 miles in a northeast direction from near Bristol and Chepstow, covering an area of nearly 1000 miles.—The mild December. The mean temperature for the month in the north-